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Biofuel developments in Sweden and the Netherlands Protection and socio-technical change in a long-term perspective

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ABSTRACT

This paper reviews long-term development of biofuels in Sweden and the Netherlands. In particular this paper explores the social dynamics of 'niche protection'. The Swedish and Dutch cases are analyzed by means of the Strategic Niche Management (SNM) perspective extended with insights from political science. Our main argument is that the development of biofuels and the way this development is protected relies on a variety of actor strategies and (local and global) discourses. This case therefore suggests that policy making for biofuels is a complex and non-linear process that can only partly be managed by policy actors.

Contents

1. Introduction

During the Second World War, biofuels like wood gas and ethanol have been used as emergency fuels in many European countries. However, once the severe conditions during this last era disappeared, interest in those fuels quickly evaporated and consumers returned to the use of gasoline and diesel. After the oil

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crises of the 1970s, renewed interest in alternative fuels emerged. The industrialized world suddenly became aware of its extreme dependency on the import of cheap fossil fuels. Other reasons to start a search for substitutes included urban smog due to heavy traffic and, more recently, the need to reduce the emissions of greenhouse gases. Despite several policy initiatives, it proves to be very hard to displace the incumbent fuels. Without protection biofuels do not stand any chance against the fuels produced from oil. In Europe the main instrument used to promote biofuels is a tax exemption through the implementation of the 2003 European Directive (2003/30/EC) on biofuels.

The directive has pushed member states' activities to search for alternatives to fossil fuels in the mobility sector. The directive was not the first European Commission's attempt to stimulate green fuels. Over the past two decades, the commission has been supporting biofuels through research and demonstration projects. The main biofuels produced in Europe are based on sugar beet, wheat and rapeseed, which are converted to bioethanol and biodiesel. The total contribution of biofuels in the mobility sector however, remains limited: biofuels contributed less than 1% of total European transport fuel consumption in 2003 [1]. Moreover, the target for 2010 is 5.75%, but most countries including the Netherlands will most likely not reach this target. One of the few exceptions is Sweden.

Recently the dramatic shift in the debate on biofuels for the transport sector – from a highly promising and sustainable to a technology leading to more harm than good – has complicated reaching policy targets. The most crucial issue is the competition of biofuel feedstock with the food market, coupled to the idea that biofuels are to blame for the current increase in food prices and starvation in less developed countries. Other issues are deforestation, loss of biodiversity and bad working conditions in feedstock providing countries. Policy measures to protect biofuels seem to have lost any societal and political legitimacy. This indicates an often neglected or taken for granted dimension of supportive policy measures: legitimacy of alternative technologies highly depends on the general perception of the alternatives. In this paper we show that this perception in turn is shaped by dynamic societal discourses linked to those new technologies.

The aim of this paper is to enhance our understanding of the relationship between social dynamics and technological change in the biofuel field. We do so by giving ample space to describing long-term biofuel development and application in Sweden and the Netherlands and derive conclusions through comparison and interpretation. Before presenting the case studies, we discuss our approach in the next section.

2. Theory and method

To focus and structure the cases we utilize two types of conceptual lenses, Strategic Niche Management and the political science concepts of Advocacy Coalitions and Discourses. Strategic Niche Management (SNM) is part of an ongoing research program that started with the question why many sustainable innovations never make it to the market and get stuck in laboratories or showrooms (see Schot and Geels [2] for an overview). Building upon insights from evolutionary theory, history of technology and sociology of technology and creating a still growing database of empirical case studies, SNM scholars have contributed a major role to niches as protected spaces for radical innovations (see Van der Laak et al. [3] and Raven et al. [4] for references to published material). Niches – either distinct markets with diverging demand features or proto-markets intentionally created by public funds – act as test-beds for potentially radical innovations that would otherwise not survive.

Protection is necessary because prevailing rule-sets and institutions create major disincentives for potentially disruptive technologies. These, so called socio-technical regimes (from here on called regimes) refer in the case of biofuels to institutions and rule-sets connected to fossil fuels. Examples of these rule-sets are formal laws and regulations, but also routines and usual ways of doing things (e.g. mobility patterns). Sunk investments in factories and infrastructures and power positions of major industries all play a role in the stabilizing effects of these regimes. SNM scholars therefore argue that major regime changes only occur when developments in the external context – referred to as the socio-technical landscape – are successfully translated into substantial regime pressure.

Stability of prevailing regimes is one part of the explanation why radical innovations have a hard time breaking through. Building upon results from case studies and borrowing insights from innovation studies SNM scholars also explain observed failures in sustainable technology introduction by a variety of niche-internal reasons [5,6]. These include a poor articulation of expectations, a lack of user and outsider involvement in the social networks involved in niche market experimentation, and a limited learning process, focusing only on techno-economic optimization while neglecting user preferences, the regulatory and political environment, infrastructural constraints, power plays and other social and systemic dimensions. The policy advice, hence the 'management' aspect of SNM, following these insights is to create (temporary) protected spaces (technological niches) and exploit these spaces to stimulate the articulation and alignment of different actor expectations, to set incentives for creating heterogeneous networks and to organize a broad and reflexive learning process.

The second conceptual lens we use comes from political science, in particular the concepts Advocacy Coalition and Discourse. Unlike the SNM perspective that refers to the creation of protection through public policies as a fairly straightforward act, political sciences have pointed out that policy making is a lengthy, non-linear and complex process involving multiple actors. Hence, relevant actors influencing the policy process are part of various government levels and agencies, journalists, interests groups, firms, researchers and policy analysts [7,8,9,10]. These actors have different interests and values and form advocacy coalitions to strive for specific purposes and outcomes of the policy process. Others with different interests and values do the same, leading to a debate about agenda setting (which problems to solve) and policy outcomes (how to solve the selected problems).

The recent rapid changes in the biofuel debate suggest that discourses – storylines and specific ways of positioning and interpreting events and developments – may be a crucial part of strategies employed by advocacy coalitions. Discourse scholars emphasize that discourses are performative: language, text and symbols have power, do something with actors, and once accepted become institutionalized in social norms, regulations and other institutions. Consequently, those who control the dominant discourse can control the direction of change. In this perspective discourses are a resource for advocacy coalitions to articulate problems, put pressure on regimes, and promote solutions.

In the following sections we analyze and compare two case studies by means of these conceptual lenses. The two case studies describe niche market experimentation with biofuels in Sweden and in the Netherlands in the period 1973–2007. The selection of the countries is based on their varying success in biofuel development. Sweden is selected since it is one of the most successful cases of biofuel development in Europe. The Netherlands on the other hand has had less success despite field experimentation with biofuels already in the early 1990s. The

cases draw upon a variety of sources including research reports, newspaper articles, policy documents, personal communication and websites.

We analyze the development of biofuels by first drafting the general biofuel developments in both countries. We discuss the experiments performed, the social networks involved, the type of expectations articulated, the lessons learned in the experiments as well as the developments in wider socio-technical regimes and the exogenous landscape that are of relevance for biofuel development. As a second step this SNM story is approached by the perspective of Advocacy Coalitions and Discourse analysis. Two levels of discourses are distinguished, on the one hand there are the general discourses, such as the environmental discourse or the oil dependence discourse, on the other hand there are the specific discourses linked to particular types of biofuels, like biodiesel, ethanol or advanced versus conventional biofuels. The dynamics of these discourses are analyzed by zooming in on the strategic actions of advocacy coalitions.

3. Biofuel development in Sweden

Biofuel development in Sweden started quite early. Like in most European countries, all kind of alternative fuels were produced and used because of oil shortages during the Second World War, but Sweden continued to support the production of alternative fuels because of political and military reasons. In particular, the production of ethanol from sulphate lye – a waste product of the paper pulp industry – was heavily subsidized to secure industrial alcohol production for the chemical industry in case of war or other international crises [11]. This formed the starting point for the development of biofuels after the first oil crisis in 1973. We will focus here on the main development routes, that is the production of alcohols (methanol and ethanol) and gas (natural gas, biogas), and we discuss only very briefly other options (biodiesel, DME, hydrogen).

3.1. Methanol

Swedish carmaker Volvo responded to the 1973 oil crisis by promoting methanol as a potential substitute for gasoline [11]. The potential of methanol seemed larger than that of ethanol because it was cheaper, easy to produce from natural gas and fit with a greater variety of feedstock [12]. Volvo also expected that the use of methanol could provide substantial environmental benefits because of lower emissions and a reduction in the use of lead. The ideas of Volvo were received favourably by other actors from the automotive industry and by the Swedish government [13,11]. This resulted in the foundation of the Swedish Methanol Development Company (SMAB) in 1975. SMAB was a joint venture of the government (60%) and Volvo (40%). The main goal of SMAB was to investigate the use of methanol. SMAB received the major part of the R&D funding of alternative fuels during the 1970s (see Table 1), by means of which small-scale trials were carried out with methanol blends and with pure fuels in various types of vehicles. In particular the promise of M15 (a blend of gasoline with 15% methanol) rose due to the low adjustment costs for vehicles and similar trends abroad [11,14].

Table 1
Government funding to alternative fuels 1975–1981, in million Swedish crowns (MSEK).

Motor fuel	Funding (MSEK)
Methanol	75.7
Ethanol[a]	3.5
Synthetic petrol	7.7
Gases	1.0
Not fuel specific	14.5

Source: [14].
[a] The ethanol research funding started later. Limited funding was given in 1979–1981).

Starting in 1979, the government funded a large-scale trial with 1000 M15 vehicles with a complementing fuel distribution network all around Sweden [14]. This initiative got a major boost because of the second oil crisis of 1979. Oil substitution in the transport sector became a major policy issue: alternative fuel development funds were doubled, the focus on alternative fuels was broadened, and a two-step implementation plan was presented. The first step suggested the introduction of fossil methanol by means of imported feedstock (natural gas) and known conversion techniques. In a second step domestic raw materials like wood and peat were to be used to reduce fuel dependency. An important condition was a successful development of the biomass gasification technology [15].

Although the M15 experiments were quite successful, a government bill in 1981 change focus to pure methanol (M100) because of its larger environmental and oil substitution potential. The same bill gave a tax exemption to alcohol fuels as a response to the methanol lobby. In this way, a disadvantage of methanol, that has a 50% less energy content compared to gasoline, was compensated. Two years later budget was provided for a large-scale M100 trial in fleets, including 200–300 cars and 100 buses. These vehicles were mainly Flexible Fuel Vehicles (FFV) provided by Swedish carmakers Volvo and Saab-Scania [14].

Several landscape developments reduced the methanol ambition from the mid-1980s onwards. The fall of the oil prices reduced the urgency of oil substitution. The Chernobyl accident shifted the attention for oil substitution to the background. Although the promise of gasification technology remained strong, continued efforts in this field focused on the production of gas for the generation of electricity.

3.2. Ethanol

Another option emerged in the context of the agricultural regime. The sugar industry could not compete on the international market – in fact sugar production in Europe only has survived because of large-scale protectionism – and overproduction of wheat stimulated interest of agricultural organizations in the production of ethanol. Brazil and, to a lesser extent, the USA demonstrated the viability of the ethanol route. Consequently, the agricultural actors started to lobby for ethanol [16]. The strong position of the Centre Party, representing farmer interests in the government, resulted in the inclusion of ethanol in several official reports and government white papers on alternative fuels in the late 1970s. As part of a transition phase, the Swedish government started to use the word ‘alcohol’ to refer to the potential of both methanol and ethanol. While ethanol was still considered an expensive complement to methanol, the interest in ethanol grew throughout the 1980s [14]. The main advantage of ethanol was that it could be produced from domestic and renewable materials on a short term, contributing both to the goals of national security and reduction of environmental impact through oil substitution [16,17]. In addition, the 1981exemption on fuel tax for alcohols, mentioned above, worked out even more favourable for ethanol because it has a higher energy content compared to methanol and thus gained a tax advantage compared to gasoline [14].

A first attempt to convert a sugar beet factory into an ethanol factory in the late 1970s, failed before implementation because the expected costs were too high [12]. But once the ethanol lobby had secured support, the Federation for Swedish Farmers (SLR) and the

industrial company Alfa Laval, built an ethanol plant based on wheat in Lidköping in south Sweden [18]. Funding was received from the government, which enabled ethanol production between 1984 and 1987. Also included in the network was the oil distribution company OK, that started to distribute the ethanol in a 4% mix in its gasoline. Once the trial ended in 1987, the agricultural lobby proposed and planned a new and larger plant [19]. Nevertheless, not enough financial support could be found and no agreement could be reached with the oil industry for the extension of the ethanol distribution. Negotiations dragged on until 1998, when both the government and the EU granted the farmer lobby a tax exemption to produce 50,000 m^3 a year. EU approval was necessary, because Sweden had become a member of the EU in 1995, meaning it had to conform to EU tax regulations, only allowing exemption for pilot project limited to time and a type of fuel [14].

A parallel network in the north to that of the wheat farmers in the south was formed in 1983. In cooperation with the industrial ethanol production plant in Örnsköldsvik (north Sweden), local municipalities, regional authorities, a farmer organization (LRF) that also represented forest owner's interests, the chemical processing companies (Berol Kemi and SEKAB) set the Foundation for Swedish Ethanol Development (SSEU). Their aim was to explore the potential to produce and use local wood ethanol (or cellulose ethanol) as fuel. Financial support came from the Ministries of Industry, Defence and Agriculture [14]. The SSEU started by setting up small-scale trials with ethanol in public transport buses in Örnsköldsvik and eventually in Stockholm in the late 1980s, using Scania's technology developed for the market in Brazil. The ethanol used in the trials was partly from the industrial ethanol production plant, based on a waste stream from the pulp and paper industry, and partly imported wine ethanol from France [20]. In addition, SSEU initiated cellulose ethanol research in cooperation with universities. The reason was that the production of ethanol from wood, promises higher efficiencies than the traditional ethanol production method from sugar and starch.[1] However, this technology was still in a developmental stage. The SSEU lobbied for a cellulose ethanol pilot plant, but for over a decade researchers declined to participate in such a project [14].

Through its political connections to the Centre Party, SSEU managed to acquire additional funding both for research and for scaling up the ethanol bus project in the early 1990s. However, the diffusion and up scaling of projects was hampered by external developments. Reorganization of public bus companies led to cut backs in alternative fuel trials. SSEU decided to start a parallel project for ethanol cars by importing Ford FFVs from the USA, as Swedish car manufacturers were not willing to cooperate despite know-how in the field of alcohol engines. In collaboration with OK, trials with ethanol pumps and cars were set up locally in Örnsköldsvik. As a result, a commercial niche market was created at the municipal level. In 1996, 300 buses and 24 trucks were running on ethanol, mainly on E95, but also on E15. Later both ethanol FFVs and fuel pumps were spread to local authority fleets all over Sweden by means of a PR tour involving OK, SSEU and the environmental organization the Natural Step [14] (Table 2).

In the late 1990s, the government provided financial support for additional FFVs and filling stations via Local Investment Programs (LIP) for which municipalities could apply in the period 1998–2002. On demand from the Stockholm environmental vehicle organization and the government, a new generation FFVs was ordered. Again Ford was the only one willing to co-operate and a new model, the Ford Taurus FFV, was introduced on the market in 1999. Additional measures included a tax reduction on environmentally friendly lease cars in 2000, removing the price difference with conventional cars running on gasoline. Investment programs, tax exemptions and local incentives, like free parking in various cities and an exemption of congestion fees implemented in Stockholm in 2005, contributed to a dramatic increase in the sales of FFVs from 2002 onwards (see Table 3). The expanding market attracted Volvo and Saab to develop ethanol FFVs, marking their return to the alcohol car niche since the methanol car trials.[2] Recently, oil companies are also becoming attracted to the ethanol market since importing ethanol, particularly from Brazil has become profitable [14].

Table 2
RD&D funding of the use of alternative fuels and vehicles in the period 1993–1997, indicated in million Swedish crowns (MSEK).

Fuel	Government funds	Stakeholder funds	Total
Ethanol	47	73	120
Biogas	30	120	150
DME	4	9	13
Methanol	0.5		0.5
Not fuel specific	28	4	32
Total	110	206	316

Source: [14].

3.3. The comeback of methanol

In 1999 the SSEU changed its name to Bio-Alcohol Fuel Foundation (BAFF) to indicate a renewed interest in methanol, alongside ethanol. This was a result from developments in the field of biomass gasification. Work on biomass gasification had continued mainly in relation to the generation of electricity, but increasing prospect for biofuels attracted attention from other actors. One of the central actors pushing for the development of methanol was the consultancy firm Ecotraffic, set up by former employees of SMAB. Together with the city of Trollhättan, Ecotraffic attempted to build a methanol plant in the mid-1990s by means of EU funds, but without success. Close cooperation between Ecotraffic and a government actor, the Swedish Road Administration, among others, led to a new research program launched in 1999, with a clear focus on biofuels from the gasification route [14].

At the same time, the company Chemrec that had been working on gasifying a residue of paper pulp industry, called 'black liquor' since 1985, got the idea to process black liquor to methanol. A research and demonstration project was designed and already in 2004, a pilot plant was opened in the city of Piteå, in the north [14]. The gasification technology can also be linked to the other main route, the gas route.

3.4. Gas

Liquefied Petrol Gas (LPG), a by-product of the oil refineries, was first tried in Sweden in the 1970s. LPG is a cleaner fuel than regular gasoline or diesel, but it requires a bi-fuel vehicle, that is a vehicle with an extra gas tank. The use of LPG was made attractive due to a 50% tax reduction compared to regular fuels. Taxi companies were the first to introduce LPG. Eventually, LPG in taxis and cars became a market niche. However, the number of 3000 cars in the early 1980s was the peak and the niche declined drastically in the late

[1] Both cellulose and starch based ethanol use processes of hydrolysis and fermentation. The only difference is that the processes are more difficult to realize for cellulose since the sugars in the cellulose are difficult to extract.

[2] In 1999 Ford took over Volvo; the impact of this takeover on decisions to develop and introduce FFVs by Volvo in Sweden is not known to us.

Table 3
Number of vehicles running on alternative fuels or electricity.

Number of vehicles	2000	2001	2002	2003	2004	2005	2006	2007
Light vehicles								
EVs	600	–	500	450	400	360	320	310
Electric hybrids	250	350	530	620	1,350	3,300	6,100	9,400
CNG–biogas	1500	1640	2,500	3,440	4,500	6,600	10,500	12,900
Ethanol FFVs (E85)	250	890	3,500	7,980	13,300	21,400	46,700	81,300
Heavy vehicles								
Ethanol buses	–	–	–	400	380	370	490	490
Gas buses and trucks	–	–	–	680	780	900	1,120	1,160
Electric and fuel cell	–	–	–	17	18	13	9	10

Source: Miljöfordon (www.miljofordon.se/fordon/antal-fordon–mangd-bransle.aspx visited at 10.04.2008).

1980s. One reason mentioned is the announcement of the government to increase the LPG tax. While this never occurred during the 1980s – in fact taxes were reduced – the trust in LPG was lost [21]. The sudden availability of natural gas in the mid-1980s, is also likely to have contributed to the decline in LPG sales.

Natural gas became an option because the discovery and start of the exploitation of natural gas (and oil) in the North Sea from the late 1960s onwards [22]. Sweden became interested in natural gas after the 1980 referendum on nuclear energy leading to the decision to phase-out nuclear technology in 2010. Natural gas was seen as a potential substitute for nuclear energy and in 1981 the government decided to build a pipeline from Denmark to Malmö, and via Gothenburg to Stockholm. The first delivery of natural gas to Malmö started in the mid-1980s [23]. A few years later, in 1988, Malmö initiated a natural gas bus trial with Scania's buses previously running on LPG. Once the natural gas pipeline was drawn to Gothenburg, Volvo bus trials started in Gothenburg in 1992. The main argument for natural gas buses was improvement of the inner city environment. The success of the CNG buses and the expected expansion of the natural gas pipeline led to commercial production of CNG buses by Volvo and Scania.

The expected pipeline from Gothenburg to Stockholm, induced Stockholm and cities on the planned trajectory (Linköping, Trollhättan) to start research and experiments with biogas in order to 'prepare' for the coming gas infrastructure. This involved the setting up of biogas installations (not based on gasification but on anaerobic digestion of biomass), development of technology for upgrading biogas to natural gas quality and preparing for a biogas bus project in Linköping [14].

However, the following years the focus shifted. In 1991 the government decided that the natural gas pipeline was not to be continued to Stockholm in order to prevent competition with biomass alternatives, primarily in the energy sector. This was part of the same political agreement that created more space for ethanol development, including providing large funds for scaling-up of ethanol bus trials. Part of the funds went to biogas projects, mainly because of the increasing promise of biogas as a sustainable and clean option.

Tax exemptions for biogas were also realized in negotiations with the EU. Hence, also biogas projects could profit from tax exemptions within the EU framework. As a result, the planned biogas bus trial in Linköping was carried out between 1992 and 1994 and a parallel trial was set up in Trollhättan. The city of Uppsala joined 1996 and even Stockholm that had withdrawn from the biogas network for a moment, joined the biogas network in 1997. The result was 49 biogas buses running in 1997. Despite the halt of the expansion of the CNG pipeline and the increasingly independent development of biogas, the two gas niches continued to develop side by side. One example was the take-off of gas cars in Sweden, as a result of a media hype which occurred around CNG prototypes developed by Volvo for the World Athletics Championships in Gothenburg in 1995. While the technology had been developed for CNG, it was equally profiting for biogas because it used the same engine technology [14]. In addition, both types of fuels benefited from an official Swedish fuel standard, established in 1999 [20] and the coming about of a tax reduction for green leasing cars. However, the Local Investment Program (LIP) initiated by the government in 1998, was particularly beneficial for biogas that became the number one funding object. Out of 1500 vehicles funded by the LIP program, 1100 were biogas vehicles and in 2003 16 out of 34 biogas filling stations were financed in the same way. But again, the biogas cars could just as well be fuelled with CNG. Both CNG and biogas cars fall under the definition of 'environmental cars'. Hence, the additional privileges (e.g. free parking and exemption of congestion fees) for gas cars stimulated the development even further. In parallel to these developments, a large biogas network evolved in the Gothenburg region around the turn of the century, involving companies, interest organizations and the nearby cities. Cooperation was set around a large sewage plant producing biogas for the region and strong ties are still kept with CNG actors [14].

3.5. Biodiesel

Natural gas has not only been used as direct gas fuel. At the end of the 1990s, Oroboros AB (after 2006 Ecopar AB), a company from Gothenburg, succeeded in producing Fischer-Tropsch (FT) diesel from natural gas. In 1999, the first fuel, called Ecopar, was produced. Since Ecopar diesel is substantially cleaner than regular diesel, the company aimed at niche markets where emissions have a direct impact, e.g. in inner city or environmentally sensitive areas.[3] A promise of FT-diesel is linked to the biomass gasification trajectory, because natural gas could be substituted by synthetic gas from biomass in the future [14].

Before the emerging interest in FT-diesel, there had been experiments with rapeseed methyl ester (RME) in Sweden, but these experiments did not attract much interest. The production of RME is a rather simple process in which a pure vegetable oil (PVO) is converted to biodiesel through estherifaction. Rapeseed is the main crop, but sunflower seeds or olives can also be used. According to Sandén and Jonasson [14] interest in RME appeared among farmers in the late 1980s and a few small-scale production and trials were set up. However, the government provided no financial support to these projects. The main argument was the limited area (35,000 m^3) available for rapeseed cultivation. This did not fit within the idea of large-scale substitution of the fossil diesel use. Moreover, the rapeseed cultivation was heavily subsidized and Sweden's entrance in the EU made an end to this practice. In addition, emission tests of the time indicated that RME was less environmentally friendly than other alternatives [14].

[3] http://sv.wikipedia.org/wiki/Ecopar visited at 30.03.2008.

Despite the declining interest in the mid-1990s, an official Swedish standard for RME was developed in 1996 [20]. While RME remained a contested option, it gained increasing use as a low blend fuel in diesel due to its relatively low production costs compared to ethanol. In 2005, the farmer lobby even manages to gain support for the construction of an RME plant [14].

Parallel to the RME development trajectory, developments of a new diesel fuel, dimethyl ether (DME), became a niche linked to the gasification track. DME can be produced out of natural gas or synthetic gas based on biomass or fossil feedstock. It is a clean, multi purpose synthetic fuel that does not contain contaminants. After several feasibility studies pilot projects have started, e.g. by Volvo [14].

We can conclude that biofuel niches have development successfully in Sweden. A market niche exists for biogas and ethanol vehicles and other alternative fuels are well on track onto commercial introduction. Also work on more advanced fuels, continues in R&D niches.

4. Biofuel development in the Netherlands

In the Netherlands LPG was the first alternative fuel. Due to tax advantages, LPG was particularly attractive for high mileage drivers and a whole industry was set up to construct, install and distribute LPG and LPG technology. In 1997 almost 500,000 cars were running on LPG in the Netherlands, second only to Italy.[4] LPG was a logical choice for the Netherlands, due to the presence of major oil refineries in the Rotterdam area. Moreover, oil companies Shell and Esso were, together with the national government, the major players in the natural gas regime that dominated the gas field in the Netherlands since the early 1960s. Therefore, the production and marketing of CNG has not been explored, until recently.

Another difference to Sweden is the increasing share of diesel; from 2000 onwards, diesel has a market share of more than 50%.[5] It can partly be explained by the large transport sector in the Netherlands. Experiments with biofuels started later in the Netherlands. The two main routes are the ethanol and the biodiesel route (RME, PVO, FT-diesel) [1] (Table 4).

Table 4
Biofuels for road transport; distribution domestic market.

	Distribution in million liters					Distribution in % of total distr.				
	2003	2004	2005	2006	2007[a]	2003	2004	2005	2006	2007[a]
Ethanol	–	–	–	38	176	–	–	–	0.55	2
Biodiesel	4	4	3	29	283	0.05	0.05	0.04	0.35	3.24
Total	4	4	3	67	459	0.03	0.03	0.02	0.43	2.75

Ethanol is expressed as the percentage of the total distribution of gasoline, biodiesel as the percentage of the total distribution of diesel. The total ethanol and biodiesel distribution is expressed as the percentage of the total gasoline and diesel distribution.
Source: Statistics Netherlands (www.cbs.nl, visited at 01.07.2008).
[a] Numbers are tentative.

4.1. Ethanol

Overproduction was the main problem in the agricultural sector. As a response, the Agrification Movement was initiated. The main aim was to improve the competitiveness of the agricultural sector by looking for alternative products and applications for agricultural feedstock [24,25]. In this context sugar producing co-operations of farmers and the alcohol producing industry formed the organization 'Bio-ethanol from Agricultural raw materials' (OBL) in the 1980s [26]. OBL set up a network together with the Groningen bus company Gado, the local Agricultural Board, Mercedes and the research institute TNO. By means of tax exemptions from the Government they started a trial with three ethanol buses in 1992. The argument for ethanol implementation was not only environmental (reduction of smog, led and CO_2 emissions) but also the support of farmers. Despite technical problems, the trial was evaluated as successful, but ethanol was considered too expensive for follow-up trials [27].

The sugar lobby contested this assumption of ethanol as too expensive. They lobbied for an ethanol production plant for the alcohol producing company Nedalco. The plant should demonstrate the feasibility of large-scale production of ethanol based on sugar beet and starch crops. In a later stage, cellulose based ethanol production could be implemented. The benefits for the climate and for the local farmers were still the main arguments used [28].

Eventually, the lobby succeeded in acquiring political support in the Dutch parliament. Within the framework of a new CO_2-reduction plan, Nedalco received a remarkable large tax exemption of 61.3 million guilders over a period of 10 years in combination of an investment subsidy of 6.8 million to construct the plant and develop the production process [29,30]. The EU gave the necessary consent and the project was ready to be launched. However, the business partners of Nedalco decided to withdraw from the project and the tax exemption as well as the subsidies remained unexploited [31]. After this drawback, Nedalco joined forces with the Canadian company Cerestar in order to build an efficient conventional ethanol plant that in the future would be able to process increasingly more woody and agricultural waste related biomass [32]. However, while the plans for the plant were already announced in 2002, in 2006 still no final decision had been made with regard to the construction of the plant [33].

While cellulose ethanol became perceived as one of the most promising options in the end 1990s [34], Nedalco continued its plan to develop cellulose ethanol with several partners, such as the research institutes ECN, TNO and a number of universities, in different projects funded by the Government from 1998 onwards [27]. The cooperation has evolved in an ethanol cellulose platform in the Netherlands [35]. Nedalco's network is also of international character, including Swedish and Finnish researchers and companies [36]. A successful project with the Universities of Delft and Nijmegen, resulted in the isolation of a fungus that can be applied to the conversion of wood into ethanol, a central process in the wood ethanol conversion process. This process was patented by Nedalco and its partners [37]. As a result the plans to construct a conventional plant were abandoned in favour of a pure cellulose ethanol plant. In 2007, Nedalco reached deal with the American company Mascoma that has complementary know-how with regard to the cellulose ethanol production. Production in the new plant is expected already in late 2008 [38,39].

There were also some initiatives to create a market for ethanol vehicles. From 2000 onwards, the Municipality of Rotterdam became a key actor lobbying for the set up of an ethanol market. Rotterdam wanted to start with ethanol FFVs for its own vehicle fleet. Partners were Nedalco, Ford, Roteb Lease and a couple of fuel distributors [40]. Again implementation was quite slow: the first 20 FFVs were not introduced before the fall of 2006 [41].

4.2. PVO/biodiesel

Trials with PVO started in the early 1990s. Developments in Germany served as an example. A private entrepreneur, Moeken, decided to set up local production of the PVO Elsbett engine, developed by the German engineer Elsbett. The local government

[4] www.cbs.nl visited at 10.07.2008.
[5] www.cbs.nl visited at 10.07.2008.

in Groningen and a local development association (NOM) were willing to provide funding, but they withdrew in the last minute because of doubts on the business plan [42,43].

The second attempted PVO experiment, set up by father and son Aberson and their company Solar Oil Systems, was more successful. Having acquired personal experience with the Elsbett technology in Germany, the son started to adapt diesel cars to run on PVO. The main argument of the Abersons was protection of the environment by local production and use of biofuels. The Abersons decided to team up with the farmer organization NLTO to set up an oil mill for the production of PVO, the North Netherlands Oil Press [44]. Together with the Province of Friesland, a leading actor in the biodiesel lobby, they started lobbying for a tax exemption. In 2002 a tax exemption was granted for a variety of biodiesel and PVO projects [45]. The tax exemption gained for the North Netherlands Oil Press, covered 3.5 million liters PVO in the period 2002–2010. However, due to on going discussions on the merits of PVO, the construction of the oil Press was delayed until 2005. A parallel project that also profited by the tax exemption was the Organization for Plant Oils and other Ecological Energy Sources (OPEK) that also constructed an oil mill on the basis of a tax exemption. However, OPEK's project was less successful because they were mainly surrounded by sugar beet farmers who were, contrary to the expectations, not willing to cultivate rapeseed [3].

The Aberson initiative was also successful in terms of replication and dissemination. To support market formation, Aberson imported German PVO and they assisted in reconstructing PVO vehicles. Follow up projects included the adaptation of the sweeping cars of the Municipality of Venlo in 2002 and refitting waste trucks of McDonalds to run on PVO in 2003. Trials were successful and the network expanded to other regions, including a hybrid bus trial, using PVO and diesel, in two local buses in Brabant [46]. The Abersons started a garage for refitting diesel cars and they also managed to set up the first PVO pump [47]. However, it was the oil distribution company Delta Oil that set up the first commercial filling station in the northern part of the Netherlands providing both biodiesel and PVO [48]. In the southern province of Limburg a second mill became operational in 2005 [3,49]. In this way a small market niche was constructed, but further expansion was hampered by an emerging societal debate on biofuels.

Parallel to the PVO experiments a biodiesel bus project was set up by the local transport company RET together with Volvo, fuel producer Novamont and the local municipality in Rotterdam in 1992 [50,27]. Additional funding by the EU enabled the prolongation of this trial with additional buses until 1995. While the project was considered a success despite some technological problems, the perceived lack of economic viability was a barrier for continuing the project [27].

Two boat rental companies in the province of Friesland organized another biodiesel experiment. The main trigger for this trial was the increasingly stringent water pollution norms in the 1990s. Biodegradable biodiesel was promoted as a solution because it could substitute regular diesel. The trial started in 1995 with 70 boats from the boat rental companies and was followed by three additional trials, a fleet of seven boats owned by the Province of Friesland, six boats of companies running water-buses in the Amsterdam canals and a ship from the authority of waterways in the Netherlands. All these projects were made possible by temporary (and limited) tax exemptions. Once the tax exemption ended, the province of Friesland and northern farmer organizations lobbied extensively for continued support. In particular, provincial authorities expressed great ambitions of setting up a biodiesel cluster and becoming a centre for sustainable development. The Amsterdam canal boats however, already had a general tax exemption on all mineral oil; hence they were able to continue the trial. Eventually, after four years of lobbying, a new tax exemption for the period 2002–2005 is given to the cluster of boat experiments in Friesland [27].

With regard to biodiesel production, initial plans in 2002 to set up a plant were not successful [51]. The companies Biovalue and Sunoil Biodiesel were more successful, opening plants in 2006 and 2007, respectively. Due to the uncertainty of the biodiesel market in the Netherlands, these plants produced biodiesel for the booming German market and, consequently, no deals were made with Dutch farmers [52,53]. More recently, new biodiesel plants are under construction and one is realized using waste stream as feedstock, e.g. animal fats [54].

Apart from the biodiesel and PVO trials, more advanced diesel fuel technologies were developed in the research domain. Researchers regarded biodiesel, PVO and ethanol, using agricultural crops as feedstock, as inefficient and having little impact on the reduction of greenhouse gases; these biofuels compared unfavourably to the co-firing of biomass in power plants. They introduced the label 'first generation' for these biofuels, in order to be able to stress the need to develop more promising, so called 'second generation' fuels [55]. Second generation fuels referred to cellulose based ethanol, FT-diesel, DME and oils based on pyrolysis technology or Hydro Thermal Upgrading processes. The increased attention to CO_2 reduction at the end of the 1990s was used to design and implement the GAVE program [34].

In fact, several research lines were explored and developed in the Netherlands. Hydro Thermal Upgrading of wet biomass (HTU) was the earliest option developed by Shell in the early 1980s, but Shell lost interest after the decline in oil prices. Two Shell engineers continued work on the HTU process in the company Biofuel B.V. Later on, Shell returned to the HTU network [27]. Together with TNO and the Biomass Technology Group (BTG), Shell and Biofuel set up a pilot plant in Apeldoorn with an investment grant of €5 million from the government [56,57]. Although the pilot plant is realized and the promise of HTU is kept alive with additional funding, the next step, scaling up, has not been achieved.

The main theme in the field of biodiesel research is however, Fischer-Tropsch (FT) diesel, which since the late 1990s was declared the most promising biodiesel option in terms of CO_2-reduction potential and cost efficiency [34]. Within the GAVE program, two parallel research projects were set up. The first one, a cooperation between a research platform, Shell, the Dutch energy research institute ECN, Rabobank and Volkswagen, focused on the potential of producing FT-diesel, electricity and heat in a biomass gasification installation [58,59]. The second project was carried by TNO, the Dutch energy distribution company Nuon, Sasol Technology, a South African company with experience with FT-technology, and Demkolec, the Dutch company set up for the exploitation of a large coal gasification plant in the province of Limburg. This network wanted to research the production of FT-diesel from synthetic gas (SNG) produced by co-gasification of biomass [58]. Both projects did not result in setting up a demonstration plant for FT-diesel; the main reasons mentioned were severe bottlenecks in gas cleaning and limited financial support [60]. While research activities continued on gas cleaning in the Netherlands, Shell decided to move its activities to Germany; it bought a minority share in the German gasification company Choren in 2005. Choren claimed to have a working SNG production process and intended to set up a large-scale plant and commercialize FT-diesel under the name Sun Fuel in Germany in cooperation with Volkswagen. It is not clear whether this plant has been built and is operational [61].

Another option appearing in the late 1990s is DME. DME was introduced by TNO in 1997 and although initial evaluations regarded DME as promising, it could not compete with the positive

expectations of FT-diesel [62]. Hence, the option did not become part of the Dutch research agenda.

Biofuel niche development in the Netherlands seems to be characterized by a dual track approach. A small PVO/biodiesel niche emerged, but this is not very visible. In order to comply with the EU directive on biofuels, setting a target for a 2% biofuel mix in 2005 and a 5.75% mix in 2010 [63], the Dutch government chose for obliging oil companies to distribute an amount of biofuel equal to 2% of the total amount of transport fuel distributed, starting in 2007. The plan is to increase the amount of biofuel distribution successively. Moreover, there are hardly any filling stations providing pure, or high blend, biofuels in the Netherlands. The second research driven track focuses on advanced fuels, but this has not led to any large-scale experimentation. Advanced fuels remain a promise.

5. Sweden and the Netherlands: a comparison

The development of biofuel niches in Sweden and the Netherlands show remarkable differences. First of all, developments in Sweden started much earlier than in the Netherlands and in Sweden a few viable market niches seem to have developed, one on ethanol and another on (bio)gas. In the Netherlands the biodiesel niche seems to be much more fragile. Another striking difference is the implementation strategy. In the Netherlands the focus has been mainly on the supply of fuels, while in Sweden a much broader market and consumer oriented strategy has been applied, by also pushing for the introduction of FFVs or bi-fuel vehicles and offering several advantages to users of these vehicles. Moreover, supporting the conclusions of Hillman et al. [64], we see that Swedish policy measures have been much more consistent and general compared to the ad hoc measures of the Dutch government. From a SNM perspective, Sweden has clearly used a better niche development strategy.

Some of the differences can easily be explained by exogenous factors and by the composition of the social networks involved. The Swedish position as a neutral country and the lack of fossil fuel resources differ from the Dutch one. The Netherlands occupy a strategic geographical location in the flows of feedstock, including oil, and moreover, the Netherlands have been a major natural gas power in Europe. This is also reflected in the dominant position of Shell in the Dutch networks and partly explains the focus on the supply of fuels. In Sweden independence in case of emergency and the ample availability of biomass resources have led to an early and continued interest in biofuels. Also, in the Swedish networks the car industry has played a much more prominent role. The supply of FFVs can be understood from this perspective, although this has not been always straightforward as the introduction of ethanol personal cars by Ford in the mid-1990s illustrated.

A common characteristic in all biofuel trials and market development both in Sweden and the Netherlands has been the role of financial protection in the form of tax exemptions. Without tax exemptions little would have happened. This reflects partly the complicated price system and protection of the incumbent fossil fuel regime, where taxes have a major impact on the gas and diesel prices paid by customers at the filling station. Still this regime offered governments the opportunity to create space for experiments. However, to acquire tax exemptions, extensive lobbying for tax exemptions by the leading actors and their networks, involved in the experiments, was needed. In the SNM literature, little interest has been given to the way actors succeeded (or failed) in acquiring this protection. Our hypothesis is that it demands active participation in advocacy coalitions and linking local promises and expectations to more global discourses. In the next paragraph, we turn to this socio-cognitive form of protection.

6. Discourses and advocacy coalitions

We distinguish three major discourses. The first one evolved around the system of energy supply. After the first oil crisis a new discourse developed, stressing the need to reduce dependency of the oil suppliers by diversification of resources, developing alternative resources and increasing efficiency. This one we call the oil substitution discourse. A second one, the environmental discourse, emerged as a result of increasing concerns over the environmental impact of industrial societies, including the system of energy supply. Reducing emissions (NO_x, SO_2, later CO_2, particulate matter) became a major policy goal. Until 1986 the debate on the role of nuclear energy was one of the major constituents of both discourses. After the Chernobyl accident, the fall of energy prices and the increasing attention for global environmental problems, the environmental discourse gained the upper hand in both Sweden and the Netherlands, but rising oil prices and changes in the global political landscape reintroduced the oil substitution discourse this century. The third discourse refers to the agricultural discourse, which centred on the future of agriculture in Europe and the EU in particular. Overproduction and a costly and protective system of agricultural subsidies had created financial and political tensions and had become a major problem for the process of European integration. Within this context a specific biofuel discourse developed, or more precisely, several discourses around the various options and related technologies.

6.1. Sweden

The oil crisis in the seventies created great urgency to find alternatives since Sweden had no fossil fuels and was highly dependent on fossil oil. The need to reduce the oil dependency was linked to national security, consequently the oil saving and substitution discourse dominated in the 1970s and early 1980s. As a result, the development of domestic energy sources such as biomass was promoted [65]. An additional discourse was the environmental discourse, concerned with the impact of emissions on human health and environment [66]. Methanol was selected as the most promising alternative, because the Swedish car industry preferred this fuel. Volvo presented methanol produced from domestic raw materials as the solution to the oil dependency in the transport sector and as a solution for environmental concerns due to its potential to decrease emissions and to substitute lead. On the request of Volvo, a close cooperation with the government was initiated in the company SMAB [11]. The growing strength of the methanol discourse emerging from this advocacy coalition is mirrored in the funding of alternative fuel research in the 1970s and early 1980s. As shown in Table 1 above, methanol received the major part of the increasing funds. This can partly be explained by the success of the methanol experiments and the strength of the methanol advocacy coalition, but space for the methanol discourse was also created by a political compromise between pro and anti nuclear sentiments at the national level. Following Kaijser [67] and Vedung [68], a compromise was reached to freeze the already high funds for nuclear energy development while the funds for renewable energy were successively increased. The main actor behind this achievement was the Centre Party, representing the agrarian interests.

As a response to the second oil crisis, the oil substitution discourse became much more urgent, resulting in an intensification of the efforts to implement methanol as an oil substitute on a short term [66]. The initial implementation of methanol should be based on natural gas from the North Sea. On the longer term methanol should be produced from wood [15]. However, part of the scientific community opposed this option because they

considered the technology too complex and inefficient compared to the use of wood waste for the production of electricity and heat. They articulated a clear preference for synthetic gasoline, because of its excellent fit with the incumbent engine technology and infrastructure and engine technology [69,70].

The synthetic gasoline option did not get much support, but ethanol from agricultural feedstock did profit from the high political priority for oil substitution. Ethanol was promoted by agricultural interests, in the context of the emerging agricultural discourse. Worries on increasing inefficiencies of the agricultural sector, creating overproduction while being dependent on subsidies, made ethanol an increasingly attractive option [16,17]. Gradually a shift in the expectations on methanol and ethanol can be observed from 1980 onwards. To facilitate ethanol development in a time when methanol was still regarded the superior option, actors did not only promote the ethanol alternative, they also changed the vocabulary from talking about ethanol and methanol as separate fuels to the more generic term ‘alcohols’. This was visible not only in the reports of the time ([12,71,17], but also by the fact that the prominent consultant company SMAB changed the focus of ‘methanol’ in its name to ‘alcohol’ [72]. The combination of falling oil prices, that weakened the oil substitution discourse, and the increasing power of the environmental sustainable development discourse, eventually led to the temporary closure of the methanol gasification track after 1985. Following Sandén and Jonasson [14], a major element was the link to fossil fuels, created by the emphasis on the production of methanol from natural gas. They point out that, certain aspects of the methanol fuel that previously had been ignored were suddenly presented as negative traits and used to discard methanol as an option.

The new ethanol advocacy coalition was carried by agrarians in the south and industrial ethanol producers in the north. By linking up to the great wood–ethanol promises voiced in the US, wood–ethanol advocates managed, despite some opposition from agrarians, to dominate an ethanol discourse. According to Sandén and Jonasson [14], the wood–ethanol advocates presented conventional ethanol as a bridging technology for cellulose ethanol. This explains why the strong wheat ethanol advocates had to wait 10 years for support to a follow-up on the ethanol production activities initiated in the mid-1980s. Also, the use of ethanol was promoted by means of bus trials in which Volvo and Scania participated, but not as convincingly as they had done in the methanol trials.

Biodiesel from rapeseed was another option promoted by the farmer lobby in this period. However, the fact that this option was not considered environmentally friendly in Sweden, implies that it did not manage to link up with the strong environmental discourse of the time. As we have seen in the previous section, a more successful alternative emerging in the late 1980s was biogas thanks to the development of a natural gas infrastructure and a cleaner vehicles discourse. Reducing pollution in urban environments was one of the main ingredients of this discourse. CNG vehicles seemed a promising alternative, when in the early 1980s natural gas pipelines were extended to the south of Sweden to serve as a substitute to oil and nuclear energy. While no natural gas was available in Stockholm and other major cities, biogas upgraded to a natural gas standard was introduced.

Meanwhile, new negotiations on the energy policy emerged, leading to a new political compromise in 1991 [14]. The environmental discourse, fed by increasing concerns on climate change, became more prominent [73]. As a result, the (wood) ethanol advocates gained major government support for setting up a market for ethanol buses. When the municipal bus fleets ran out of matching budgets for experiments, the ethanol advocates made a strategic choice to develop the ethanol vehicle market. While the domestic car companies, Volvo and Saab, had developed FFVs that could run on methanol in the 1970s, they did not join this trial. Instead the ethanol advocates formed an alliance with Ford, which had developed the FFV technology for the American market.

In 1995, Sweden became a member of the EU, which implied adjustment to EU law and new barriers for supporting biofuel development. The extent to which tax exemptions could be given seemed suddenly very limited for Sweden. However, the Swedish government took an active role in lobbying for more tax exemptions. An early success was the adjustments of the EU laws in 1995 to enable tax exemption for biogas. Later, the Swedish lobby was directed towards the possibility to give general tax exemptions to biofuels. The growing environmental discourse in Sweden, invigorated by the upcoming Kyoto protocol, was taken up by politicians. The Swedish prime minister announced, in 1996, that Sweden should become a leading ‘green country’ [14]. As a result of the emphasis on CO_2 reduction, both conventional and advanced biofuel advocates gained increasing support.

As previously outlined, all biofuel options profited from additional tax exemptions on fuels, but also on purchasing or leasing biofuel vehicles and a series of benefits with regard to paid parking and congestion fees in selected cities. The EU biofuel policy plans, implemented after prolonged debates in 2003, seemed to confirm the Swedish approach of promoting biofuels as an answer to CO_2 reduction in the transport sector. The Swedish government [74] even increased the EU targets to a higher level, that is 3% implementation instead of 2% in 2005. Moreover, larger tax exemptions were granted than allowed according to the EU norms. This clear support for the various conventional biofuels and the setting up of a clear biofuel market brought the hesitant automobile industry back in the alcohol network.

In addition to the support of conventional fuels, we see that the strong environmental discourse creates room for an advocate coalition promoting gasification fuels, such as methanol and DME, with the promise of large-scale and cheap CO_2 reduction. Following Sandén and Jonasson [14], this coalition is build up by methanol advocates from the 1970s who have moved to various consultant companies once the methanol option disappeared. While this advocacy coalition was not strong enough to realize a first attempt to set up a methanol pilot plant in the mid-1990s, they were more successful with a novel fuel alternative, DME. Eventually, the gasification discourse is embraced by the government, public funding is given and the heavy vehicle section of Volvo takes the initiative to develop a DME engine.

In 2004, while preparing a strategy for tackling the EU Biofuel Directive, the vocabulary 1st, 2nd and 3rd generation fuels was introduced in Sweden. The 1st generation referred to conventional biofuels, 2nd generation to biofuels from the various gasification routes and cellulose ethanol and the 3rd generation to hydrogen from renewable energy sources. The general idea is that the 1st generation fuels should provide the means to reach EU goals to 2010, thereafter 2nd generation technology should increasingly become utilized [75]. In this way, the idea of bridging technologies set out by the wood based ethanol lobby in the 1980’s is still the core of the general biofuel discourse.

6.2. Netherlands

In the Dutch case, the niche analysis has showed us that the first biofuel activities start in the early 1990s. The first short-term biofuel field experiments were based on agricultural feedstock. The advocates for these experiments attracted coalition partners and acquire government funding, partly due to their ability to link-up with two general discourses in the Netherlands in that period. The first was the agricultural discourse: ‘agrification’ was proposed as a

potential solution for the problems in the agricultural sector: increasing overproduction of food and dependency on subsidies. The second discourse was the environmental discourse with a focus on local environmental problems, such as smog, and, increasingly more important, global problems such as climate change. The fact that the government did not believe in the environmental potential of biofuels based on agricultural crops [76], projects were funded only because of support to the livelihoods of farmers. Following Van der Laak et al. [3], support was given on an ad hoc basis; it was always the outcome of lobbying by local politicians and biofuel supporters with links to the national political parties. Rotterdam and its biodiesel bus trial was an exception: there were no connections to farmers and the project was funded by the EU. Following IEA [77], outlining the EU permission of temporary tax exemptions for biofuel pilot projects from 1992 onwards, it becomes clear that the EU support was no coincidence, but a result of the EU preference for biofuel development. By these means the EU contributed significantly to the Dutch biofuel advocacy coalition and their construction of a biofuel discourse.

Although most experiments were positively evaluated and the advocacy coalition lobbied for continued funding, no further tax exemptions were granted. The government blamed this on the EU rules on tax exemption [78]. According to these rules, protection should be limited with respect to time and fuel type. The negative response of the Dutch government can be explained by the emergence of an anti-biofuel lobby in the early 1990s. Scientists [79–82] repeatedly argued that the potential of using expensive food crops for fuels for CO_2 reduction is limited. Biomass, in particularly waste and wood, should be used for the production of electricity and heat because this application is cheaper, more energy efficient and reduces more CO_2. After the Kyoto protocol in 1997, CO_2 reduction became even more important, in particular for the transport sector [83]. The biomass to energy researchers, previously supporting the anti-biofuel discourse, saw an opportunity to enter the fuel domain. Central figures in this lobby are Faaij [84] and Daey Ouwens [85], who present the same concept of advanced solutions, based on wood or waste, with the promise of cheaper, more energy efficient and higher CO_2 reductions. As a result a new advocacy coalition emerged in the late 1990s, promoting advanced biofuels. As outlined in the previous section, the introduction of the concept of 2nd generation fuels was a strategic move to distinguish these fuels from to the highly criticized conventional 1st generation options. This coalition was carried by researchers at institutes and universities, but also by Shell. Because 2nd generation fuels were still a promise, mainly in the laboratory phase of development, the influence that this advocacy coalition had on government policies is showed in official white papers on energy and the large funds for RD&D projects, such as the GAVE.

Despite the strong focus on the advanced fuels set in the government's energy policy, the 1st generation advocacy coalition remained intact and even expanded. Following Suurs and Hekkert [27], both the biodiesel and the PVO networks leaned on the ever more positive biofuel discourse on the European level, focusing on agricultural feedstock, and on the success of bio fuels in Germany. The 2003 EU directive – the Dutch government opposed this directive to the last moment – forced the Dutch government to design an implementation plan. Reluctantly, a general tax exemption for biofuels was arranged for the year 2006 only. The exemption served as a preparation for a regulation in 2007 that obliged oil companies that biofuels should make up 2% of their total fuel distribution, a percentage that is expected to increase successively in order to meet future EC biofuel targets [86]. Contrary to Sweden (or Germany), the mix in conventional fuels is completely invisible. Meanwhile, the government did not give up on 2nd generation fuels; research and pilot projects for these fuels became part of the Energy Transition program, introduced for dealing with structural problems in 2001 [87].

In this period the tensions between the 1st and 2nd generation advocacy coalitions were reduced, as both profited form the high priority for reduction of greenhouse gases. However, reports on negative social and environmental consequences of large-scale palm oil production in Indonesia, used for co-firing in Dutch power plants and sold under the label 'green electricity', marked the emergence of a vehement anti-biofuel lobby. Environmental organizations demanded the implementation of very strict criteria with regard to a sustainable production of biomass [88]. The debate started with the impact of biomass cultivation on deforestation and on biodiversity [89,90], but soon turned to the competition with food production as a result of increasing food prices and emerging social unrest. Biofuels have been depicted as the main culprit by several NGOs [91]. Very rapidly, the Dutch discourse has become highly polarized. The anti-biofuel discourse has become so dominant, that the space for the development of all biofuel (and biomass) options has become seriously endangered.

7. Conclusion and discussion

This paper set out to explain the reasons for the cumbersome development of biofuels in the EU, despite the fact that initiatives to introduce biofuels have taken place as early as the 1970s. The analysis shows that there is a great variety in the composition of actor networks and context in the two cases, which is likely to have contributed to better niche development processes in the Swedish case compared to the Dutch case. The analysis shows that protection, in particular tax exemptions, has been a crucial component for successful development of biofuel in both countries. We draw three conclusions on the issue of protection, the first one on the nature of protection, the second one on who protects and the third one on the way in which protection evolves.

The first conclusion is that we have found different types of protection. The most obvious one is the creation of exemptions from general rules. One example is the various tax exemptions implemented by both countries, however, more sparsely by the Netherlands. Another one is the exemption for "environmental cars" (including biofuel vehicles) to pay parking fees in certain cities in Sweden. A step further is the creation of specific favourable rules. An example of this protection type is the implementation of congestion fees in Stockholm, which favour biofuel vehicles since they do not need to pay the fee. Another favourable rule is the increase of pollution standards, as in the case of water pollution in the Netherlands resulting in trials with biodiesel as well as the implementation of the CO_2 tax in Sweden favouring fuels with reduced CO_2 emissions such as biofuels. A complementary type of protection is the mobilization of resources, e.g. by public authorities, such as subsidies and R&D funds from the local, national and European governments, and by private industry such as Nedalco and Volvo providing matching funds or funding for own RD&D.

The second conclusion is that there are more people involved in creating protection than public authorities. Both in Sweden and the Netherlands the creation of a protected space for any of the biofuel options discussed involved dedicated lobbying by a variety of actors joined in advocacy coalitions. In Sweden methanol advocates – led by Volvo – succeeded in talking the government into a research and support programme in the 70's. Industrial alcohol and agricultural actors were the main advocates lobbying and eventually realizing support for an ethanol program. Finally, there is the biogas option that profits from the development of

natural gas and their advocats. Eventually these lobbies merged in a biofuel advocacy coalition and managed to successfully form a biofuel lobby for general biofuel tax exemptions. In the Netherlands an advocate coalition coming from the agricultural sector promoted the production of PVO and biodiesel and lobbied for tax exemptions, but they faced strong opposition from a 2nd generation biofuel coalition – dominated by energy experts and part of the industry – and later on from an emerging anti-biofuel coalition with global characteristics. These examples show that actors promoting niches are not only entrepreneurs, but also regime actors such as Volvo and the agricultural industry.

Our third conclusion is that the evolution of protection is a result of strategic actors that lobby, negotiate and mobilize discourses to reach common goals and interests. One strategy is to build advocacy coalitions with a variety of actors that may have different interests but share the same goal. Another strategy applied by advocacy coalitions, is the linking of biofuel options with dominant discourses in order to create space for niche experimentation. In Sweden the methanol advocacy coalition was very successful because they initially managed to link methanol with the oil substitution discourse and eventually even dominant environmental discourses despite the lack of technology know how on how to produce methanol from biomass. Ethanol advocates profited by the changing vocabulary into alcohols in the 1980's, which eventually made it possible to link the ethanol option to the growing environmental concern. In the Netherlands the success of the 2nd generation coalition can be explained by their successful strategy to link these advanced biofuel technologies to the general environmental discourse that is dominated by a focus on reducing CO_2 emissions. Additionally, the anti-biofuel advocacy coalition emerging in Europe today and threatening the continuance of the biofuel protection activities of the EU, show that protection is a result of negotiation. Not only between advocacy coalitions promoting different types of biofuel solutions as visible in the negotiations between the 1st and the 2nd generation biofuels in the Netherlands, but also between pro and anti-biofuel advocacy coalitions on a more global level.

Comparative to the Netherlands, the relative successful biofuel development in Sweden can be explained by a particular context and actors creating space for biofuel niche development in the first place, but also the discourses and the strategic actors mobilizing these discourses have been helpful in creating more constant protection of biofuels. The fact that these biofuel discourses have become institutionalized to a larger degree in Sweden than in the Netherlands, is likely to explain why the anti-biofuel discourse has not yet been visible in such a large degree in Sweden compared to the Netherlands. However, due to the global character of the anti-biofuel discourse, it will probably become difficult to defend continued biofuel protection in a country as Sweden as well. Particularly when considering the growing support for this discourse in Europe and the mobilization of prescriptive power that this implies.

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